MODULAR EXPANSION JOINT SYSTEM
August 5, 2002

Description
1.01 Modular Expansion Joint System

A. This item of work shall consist of furnishing material, services, labor, tools, equipment, and incidentals necessary to design, fabricate, inspect, test, and install each expansion joint system as specified.

B. Each expansion joint system shall consist of a modular, multiple seal expansion joint as designated and noted in the Plans.

C. Each expansion joint system shall accommodate the movements specified in the Plans.

D. Each expansion joint system shall extend continuously across the full width of the roadway and up into the traffic barriers as shown in the Plans.

Materials
2.01 Structural Steel

A. Structural steel shall conform to ASTM A 36, ASTM A 572 Grade 50, or ASTM A 588. Aluminum components shall not be used.

2.02 Stainless Steel

A. Stainless steel shall conform to ASTM A 240 Type 304.

2.03 Aluminum

A. Aluminum components shall not be used.

2.04 Polytetrafluorethylene (PTFE)

A. PTFE shall be 100% virgin teflon, woven PTFE fabric, or dimpled PTFE conforming to the requirements of Section 18.8 of the AASHTO LRFD Bridge Construction Specifications.

2.05 Expansion Joint Seals

A. The maximum size of each expansion joint strip seal shall be 3 inches. Box-type seals or seals utilizing double webs will not be acceptable. Seals shall be continuous without splices.

Property	Test Method	Range of Values
Hardness, Durometer A	ASTM D2240	55 -70
Tensile Strength	ASTM D412	2000psi minimum
Elongation at break	ASTM D412	250%

Compression Set, at 72 hr. at 212F	ASTM D395	40%

2.06 Bolts, Nuts, Washers

A. Bolts and other hardware shall conform to the requirements of AASHTO M 164 Type 1 or 2 and shall be galvanized in accordance with AASHTO M 232 and Section 9-06.5(3) of the Standard Specifications.

2.07 Other Materials

A. Other materials shall meet the requirements of the Standard Specifications and this Special Provision.

Construction Requirements

3.01 Acceptable Manufacturers

A. Only manufacturers whose modular expansion joint systems have met the fatigue resistance characterization requirements stipulated in Section 3.07.A of this Special Provision will be permitted to supply modular expansion joint systems. Any testing required to establish the fatigue resistance of all details of a specific proprietary system shall be completed prior to the contract award date. All fatigue testing shall be conducted in accordance with Sections 3.10, 3.11, and 3.12 of this Special Provision. Testing shall be completed on any revised details or material substitutions of a previously prequalified system prior to the contract award date.

B. The following manufacturers are known to have prequalified modular expansion joint system details by completing fatigue testing in accordance with these requirements:

1. The D.S. Brown Company
   P.O. Box 158
   300 E. Cherry Street
   North Baltimore, Ohio 45872-0158
   Tel. (419) 257-3561
   Fax (419) 257-2200

2. Watson Bowman ACME Corporation
   95 Pineview Drive
   Amherst, New York 14228-2166
   Tel. (716) 691-7566
   Fax (716) 691-9239

3.02 Submittals

A. Manufacturer Qualifications

1. The expansion joint manufacturer shall have at least three years of experience in designing and manufacturing modular expansion joint systems. The Contractor shall provide written certification of the manufacturer's experience

to the Engineer. This certification shall include the location of each bridge, installation date, governmental agency/owner, and the name, address, and telephone number of each owner's/agency's representative.

2. The Contractor shall submit the name of the selected expansion joint system manufacturer to the Engineer within 10 days of contract award. Once the name of the manufacturer has been submitted to the Engineer, the Contractor shall not select an alternative expansion joint system manufacturer unless the manufacturer demonstrates an inability to meet the requirements of this Special Provision.

B. Shop Drawings and Design Calculations

1. The Contractor shall submit shop drawings and design calculations delineating the expansion joint system to the Engineer for approval prior to fabrication of the joint, in accordance with Sections 6-01.9 and 6-03.3(7) of the Standard Specifications and as noted herein. The Professional Engineer responsible for preparing and stamping the submittal shall be an employee of the expansion joint system manufacturer, and shall hold a valid license in the branch of Civil or Structural Engineering, either in the State of Washington or another state. These submittals shall include, but shall not be limited to, the following:

   a. Plan, elevation, and section of the joint system for each movement rating and roadway width. All dimensions and tolerances shall be specified.

   b. Sections showing all materials composing the expansion joint system with complete details of all individual components including all bolted and welded splices and connections.

   c. All ASTM, AASHTO, or other material designations.

   d. Installation plan including sequence, lifting mechanisms and locations, details of temporary anchorage during setting, temperature adjustment devices, opening dimensions relative to temperature, installation details at curbs, and seal installation details.

   e. Plan for achieving watertightness including details related to performing the watertightness test required in Section 3.21.G of this Special Provision.

   f. Details and material designations pertinent to the corrosion protection system.

   g. Requirements and details related to the temporary support of the joint system for shipping, handling, and job site storage.

   h. Design calculations for all structural elements including all springs and bearings. The design calculations shall include fatigue design for all structural elements, connections, and splices.

i. Welding procedures in compliance with the current AASHTO/AWS D1.5 Bridge Welding Code.

j. A written maintenance and part replacement plan to facilitate replacement of parts subject to wear. This plan shall include a list of parts, instructions for maintenance inspection, acceptable wear tolerances, methods for determining wear, procedures for replacing worn parts, and procedures for replacing seals.

k. Any required modifications to blockout reinforcing steel to accommodate the expansion joint system.

C. Documentation, Certifications, and Test Reports

1. At the time of shop plan submittal, the Contractor shall submit to the Engineer for approval the following documentation:

   a. Documentation that the manufacturer is certified through the AISC Quality Certification Program under the category *Simple Steel Bridge Structures*.

   b. Documentation that welding inspection personnel are qualified and certified as welding inspectors under AWS QC1, Standard for Qualification and Certification of Welding Inspectors.

   c. Documentation that personnel performing nondestructive testing (NDT) are qualified and certified as NDT Level II under the American Society for Nondestructive Testing (ASNT) Recommended Practice SNT-TC-1a.

2. The Contractor shall submit to the Engineer for approval prior to fabrication the following test reports and certificates of compliance:

   a. Manufacturer's certificate of compliance for all polytetrafluorethylene (PTFE) sheeting, PTFE fabric, and elastomer.

   b. Certified mill test reports for all steel and stainless steel in the expansion joint system assemblies.

   c. Certified test reports confirming that the springs and bearings meet the design load requirements.

3. Upon completion of installation, the Contractor shall submit to the Engineer certification stating that each expansion joint system was installed in accordance with the approved shop plan installation procedure. This certification shall comply with the requirements stipulated in Section 3.21.A of this Special Provision.

D. Method for Temporary Bridging of Construction Loads

1. The Contractor shall submit to the Engineer for approval a temporary bridging method for each expansion joint system over which construction traffic is anticipated to cross following its installation. This submittal shall comply with the requirements stipulated in Section 3.21.D of this Special Provision.

E. Quality Assurance Inspection Documentation

1. The Contractor shall submit to the Engineer documentation of a Quality Assurance Inspection program performed by an independent inspection agency provided by the manufacturer. The name of the independent inspection agency, details of the proposed quality assurance inspection program including inspection frequency, and all applicable reporting forms shall be submitted to the Engineer for approval prior to the start of fabrication.

F. Warranty

1. The Contractor shall provide a five year written warranty guaranteeing the performance and durability of the expansion joint system. Conditions constituting unsatisfactory performance and durability include, but shall not be limited to, broken welds or bolts (including field splices), cracks in steel members, fatigue damage, loss of precompression in springs or bearings, debonded PTFE, breakdown of corrosion protection, and leakage. The Contractor shall replace or repair any expansion joint system component demonstrating unsatisfactory performance or durability within the five year period commencing from the date of completion of the contract. All material and labor costs shall be paid by the Contractor.

3.03 General Design Requirements

A. The expansion joint system shall be designed and detailed with adequate access to all internal components in order to assure the feasibility of inspection and maintenance activities.

B. The expansion joint system shall be designed and detailed to minimize concrete cracking above the support boxes. Measures taken shall include, but not be limited to, assuring adequate support box top plate thickness, specifying any additional roadway deck steel reinforcement required, and providing adequate concrete cover.

C. The expansion joint system and roadway deck steel reinforcement shall be detailed to assure that adequate concrete consolidation can be achieved underneath all support boxes.

D. The expansion joint seals shall not protrude above the top of the expansion joint system under any service condition. Split extrusions may be used at curb upturns.

E. The elastomeric or urethane springs and bearings shall be designed to be removable and replaceable. The removal and reinstallation of each strip seal shall be easily accomplished from above the joint with a 1-1/4 inch minimum gap width. These operations shall be viable with a one lane partial closure of the roadway.

F. The expansion joint system shall be designed and detailed to be watertight.

G. The expansion joint system shall be designed and detailed to accommodate all movements specified on the plans.

H. The expansion joint shall be designed and detailed to mitigate the potential for fatigue damage wherever centerbeam field splices are required. Consideration shall be given to reducing support box spacing and optimizing splice location between adjacent support boxes in order to minimize fatigue stress range at field splices.

3.04 Design Axle Loads and Impact Factors

A. The centerbeams, support bars, bearings, connections, and other structural components shall be designed for the simultaneous application of vertical and horizontal loads from a tandem axle. The tandem axle shall consist of a pair of axles spaced four feet apart with vertical and horizontal loads as specified in subsections B, C, D, and E below. The transverse spacing of the wheels shall be six feet. The distribution of the wheel load among centerbeams shall be as stipulated in Section 3.05 of this Special Provision.

B. The vertical load range for fatigue design shall be a 32.0 kip tandem. This tandem shall be taken as two 16.0 kip axles spaced four feet apart. Only one of these tandem axles must be considered in the design, unless the joint opening exceeds four feet. The load range shall be increased by the dynamic load allowance (Impact Factor) of 75%. Load factors shall be applied in accordance with Table 3.4.1-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition.

C. The vertical load for strength design shall be a 50.0 kip tandem. This tandem shall be taken as two 25.0 kip axles spaced four feet apart. Only one of these tandem axles must be considered in the design, unless the joint opening exceeds four feet. This load shall be increased by the dynamic load allowance (Impact Factor) of 75%. Load factors shall be applied in accordance with Table 3.4.1-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition.

D. The horizontal load range for fatigue design shall be ***$$1$$*** percent of the amplified vertical load range (LL+IM) specified in Section 3.04.B of this Special Provision. For modular expansion joint systems installed on vertical grades in excess of five percent, the horizontal component of the amplified vertical load range (LL+IM) specified in Section 3.04.B of this Special Provision shall be added to this horizontal load range.

E. The horizontal load for strength design shall be 20 percent of the amplified vertical load (LL+IM) specified in Section 3.04.C of this Special Provision. For modular expansion joint systems installed on vertical grades in excess of five percent, the horizontal component of the amplified vertical load (LL+IM) specified in Section 3.04.C of this Special Provision shall be added to this horizontal load.

3.05 Distribution of Wheel Loads

A. The following table specifies the centerbeam distribution factor as a function of centerbeam top flange width. This factor is the percentage of the design vertical axle load and the design horizontal axle load which shall be applied to an individual centerbeam for the design of that centerbeam and its associated support bars. Distribution factors shall be interpolated for centerbeam top flange widths between those explicitly denoted in the table. In no case shall the distribution factor be taken as less than 50%. The remainder of the load shall be divided equally and applied to the two adjacent centerbeams or edge beams.

Width of Centerbeam Top Flange	**Distribution Factor**
2.5 inches	50%
3.0 inches	60%
4.0 inches	70%
4.75 inches	80%

3.06 Fatigue Limit State Design Requirements

A. Modular expansion joint system structural members, bolted and welded splices and connections, and attachments shall be designed to resist the Fatigue Limit State load combination specified in Table 3.4.1-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition. The vertical and horizontal load ranges specified in Section 3.04 of this Special Provision shall be applied simultaneously. These loads shall be distributed as specified in Section 3.05 of this Special Provision.

B. The nominal stress ranges, Δf, at all fatigue critical details shall be obtained from a structural analysis of the expansion joint system applying the design vertical and horizontal load ranges specified in Section 3.04 of this Special Provision and distributed as specified in Section 3.05 of this Special Provision. The expansion joint system shall be analyzed with a minimum gap opening corresponding to the midrange configuration (at least half of the maximum gap opening). The design axle load shall be applied as two wheel loads, each having a transverse width of 20 inches. For each detail under consideration, the wheel loads shall be positioned transversely on a centerbeam to achieve the maximum nominal stress range at that detail. The vertical and horizontal wheel loads shall be applied as line loads to the top of the centerbeams at their centerlines. The design stress range in the centerbeam-to-support bar connection shall be calculated according to subsections 1 and 2 below. The design nominal stress ranges, Δf, shall be used for fatigue design as specified in Section 3.06.C of this Special Provision.

1. Welded or Bolted Single-Support-Bar Systems

a. The nominal stress range, Δf, in the centerbeam at a welded or bolted stirrup shall be the sum of the longitudinal bending stress ranges at the critical section resulting from vertical and horizontal loading. The effects of stresses in any load-bearing attachments such as the stirrup or yoke shall not be considered when calculating the longitudinal stress range in the centerbeam. For bolted single-support-bar systems, stress ranges shall be calculated using the net section.

b. The nominal stress range, Δf, in the stirrup or yoke shall be calculated without considering the effects of stresses in the centerbeam. The stress range shall be calculated by assuming a load range in the stirrup equal to 30% of the total vertical reaction force between the centerbeam and the support bar. The effects of horizontal loads may be neglected in the design of the stirrup.

2. Welded Multiple-Support-Bar Systems

Three locations have been identified as initiation sites for fatigue cracking at a centerbeam-to-support bar welded connection. The types of cracking associated with these three locations are described below. The corresponding equations may be used to calculate the nominal stress range, Δf. For the support bar, either the reduced moment at the critical cross section or the moment at the centerline of the connection may be used in these equations.

a. *Centerbeam weld toe cracking* is driven by a combination of longitudinal bending stress range, S_{RB}, in the centerbeam, and vertical stress range, S_{RZ}, at the top of the connection weld.

The longitudinal bending stress range, S_{RB}, at the bottom of the centerbeam shall be calculated as:

$$S_{RB} \equiv M_{Vcb} / S_{Xcb} + M_{Hcb} / S_{Ycb}$$

The vertical stress range, S_{RZ}, at the top of the connection weld shall be calculated as:

$$S_{RZ} \equiv R_H \cdot d_{cb} / S_{Wtop} + R_V / A_{Wtop}$$

b. *Support bar weld toe cracking* is driven by a combination of longitudinal bending stress range, S_{RB}, in the support bar and vertical stress range, S_{RZ}, at the bottom of the connection weld.

The longitudinal bending stress range, S_{RB}, at the top of the support bar shall be calculated as:

$$S_{RB} \equiv M_{Vsb} / S_{Xsb} + 0.5 \cdot R_H \cdot (d_{cb} + h_W + 0.5 \cdot d_{sb}) / S_{Xsb}$$

The vertical stress range, S_{RZ}, at the bottom of the connection weld shall be calculated as:

$$S_{RZ} \equiv R_H \cdot (d_{cb} + h_W) / S_{wbot} + R_V / A_{Wbot}$$

c. *Weld throat cracking* is driven by a vertical stress range at the weld throat.

The vertical stress range, S_{RZ}, at mid-height of the connection weld shall be calculated as:

$$S_{RZ} \equiv R_V / A_{wmid} + R_H \cdot (d_{cb} + 0.5 \cdot h_W) / S_{Wmid}$$

In the above equations:

R_V ≡ vertical reaction at the connection weld
R_H ≡ horizontal reaction at the connection weld
M_{Vcb} ≡ bending moment in the centerbeam due to applied vertical forces
M_{Hcb} ≡ bending moment in the centerbeam due to applied horizontal forces
M_{Vsb} ≡ bending moment in the support bar due to applied vertical forces
S_{Xcb} ≡ section modulus at bottom of the centerbeam about horizontal axis
S_{Ycb} ≡ section modulus of the centerbeam about vertical axis
S_{Xsb} ≡ section modulus at top of the support bar about horizontal axis
A_{Wtop} ≡ area of the weld at the top of the connection
A_{Wmid} ≡ area of the weld at the middle of the connection
A_{Wbot} ≡ area of the weld at the bottom of the connection
S_{Wtop} ≡ section modulus of the weld at the top of the connection
S_{Wmid} ≡ section modulus of the weld at the middle of the connection
S_{Wbot} ≡ section modulus of the weld at the bottom of the connection
h_W ≡ height of the weld
d_{cb} ≡ depth of the centerbeam
d_{sb} ≡ depth of the support bar

The nominal stress range, Δf, at welded multiple-support-bar connection details shall be calculated for each case above as follows:

$$\Delta f \equiv (S^2_{RB} + S^2_{RZ})^{1/2}$$

where

S_{RB} ≡ longitudinal stress range in the centerbeam or support bar, as calculated for each specific case above.
S_{RZ} ≡ vertical stress range in the centerbeam-to-support bar connection weld, as calculated for each specific case above.

C. To assure an infinite fatigue life, all modular expansion joint system structural members, connections (bolted and welded), splices, and attachments shall satisfy the following:

$$\Delta f \leq F_{TH} / 2$$

where:

Δf ≡ the nominal stress range as specified in Section 3.06.B of this Special Provision.

$F_{TH} \equiv$ constant amplitude fatigue threshold (CAFL) as specified in Section 3.07.A of this Special Provision.

3.07 Fatigue Resistance of Details

A. The fatigue resistance of all details shall be characterized in terms of the fatigue categories specified in Table 6.6.1.2.5-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition. Many details composing modular expansion joint systems may clearly correspond to specific structural details depicted in Figure 6.6.1.2.3-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition. In these cases, the applicable fatigue categories specified in Table 6.6.1.2.3-1 may be used for design. In cases where the Engineer establishes that a detail does not clearly correspond to a structural detail depicted in Figure 6.6.1.2.3-1, fatigue testing of specimens exhibiting that detail shall be conducted, in accordance with Sections 3.10 through 3.13.A of this Special Provision, to establish the appropriate constant amplitude fatigue limit (CAFL) for that detail.

3.08 Strength I Limit State Design Requirements

A. Modular expansion joint system structural steel members, connections (bolted and welded), splices, and attachments shall be designed to resist the Strength I Limit State load combination specified in Table 3.4.1-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition. The vertical and horizontal loads specified in Section 3.04 of this Special Provision shall be applied simultaneously. These loads shall be distributed as specified in Section 3.05 of this Special Provision.

3.09 Design Reference

A. Provisions contained in Sections 3.04 through 3.08.A of this Special Provision have been developed from research summarized in National Cooperative Highway Research Program Report 402 "Fatigue Design of Modular Bridge Expansion Joints", National Academy Press, Washington DC, 1997.

3.10 Fatigue Testing of Metallic Structural Components and Connections

A. Methodology

1. This test procedure is acceptable for, and specifically applicable to, establishing the fatigue resistance of the centerbeam-to-support bar connection in modular expansion joint systems. It is applicable to single-support-bar and multiple-support-bar systems having either welded or bolted centerbeam-to-support bar connections. The same methodology may be applied to establish the fatigue resistance of other modular expansion joint metallic structural component details, including centerbeam splices.

2. Each fatigue test generates a discrete datum. Each datum comprises an applied constant amplitude nominal stress range, S_r, and the corresponding number of cycles, N, associated with either a predetermined extent of crack propagation, defined as failure, or with termination of the test, defined as runout. Ten data shall be acquired for each connection detail. All data shall

be in the very long life range, corresponding as closely to the constant amplitude fatigue limit (CAFL) as practical. Specifically, the number of cycles, N, associated with each datum, shall be no less than one order of magnitude less than N_{min} corresponding to the detail category specific CAFL specified in Section 3.10.G.1 of this Special Provision. For example, to characterize a detail as Detail Category C, the tested number of cycles, N, shall exceed 4.4 x 10^5 for each datum.

3. The constant amplitude nominal stress range shall be calculated at the anticipated initiation location of an incipient crack. Nominal stresses shall be calculated using conventional equations for analyzing bending and axial load. These equations are essentially the same as those used in strength design. The stress concentration effects of a weld, bolt hole, or other local features are not explicitly embodied in the conventional nominal stress equations.

4. The appropriate AASHTO detail category applicable to fatigue design shall be established by comparing acquired test data to fatigue resistance graphs representing the AASHTO detail categories. The constant amplitude fatigue limit (CAFL) applicable to fatigue design corresponds to the AASHTO detail category fatigue resistance graph representing a lower bound of the experimentally acquired data.

5. When testing is conducted exclusively in the infinite life regime and more stringent test data scatter requirements are satisfied, a unique CAFL (different from those CAFL corresponding to specific detail categories specified by AASHTO) may be established for fatigue design.

B. Specimens

1. Specimens selected for testing shall be full-scale centerbeam and support bar assemblies or subassemblies representative of those installed in field applications. A subassembly is defined as a specimen having the same physical and geometric properties as an assembly but having a reduced number of centerbeams.

2. Each specimen shall consist of three continuous centerbeam spans over four equally spaced support bars. Centerbeam spans between adjacent support bar centerlines shall be a minimum of 3'-0" and a maximum of 4'-6". Support bar spans shall be a minimum of 3'-0" and a maximum of 3'-8". The centerbeam-to-support bar connection being tested shall be located at the midspan of each support bar.

3. Any welded or bolted attachments used to secure equidistant springs to a support bar, centerbeam, or stirrup shall be fabricated as an integral part of the specimen. A rigid load path to the test fixture shall be provided to resist any horizontal forces or displacements which would normally be resisted through these attachments in a field installation. Any miscellaneous welded or bolted attachments, including welded attachments used to secure the expansion joint strip seals to the centerbeams, shall also be fabricated as integral parts of the specimen.

4. Support bars of subassembly specimens that are components of single-support-bar swivel-joist type modular expansion joint systems shall be oriented perpendicular to the longitudinal axis of the centerbeam.

5. Prior to testing, each specimen shall be visually inspected for any defects, loose fasteners or other aberrations which could plausibly affect the tested fatigue resistance. Defects and flaws shall be defined in accordance with the appropriate governing specification (ASTM A-6, AWS D1.5, etc.). Data acquired from specimens containing such anomalies shall not be excluded from consideration except as permitted in Section 3.10.G.2.c of this Special Provision. Any observed anomaly shall also be reported with its corresponding data in the tabular format stipulated in Section 3.10.H of this Special Provision.

C. Instrumentation

1. Each specimen shall be sufficiently instrumented to measure the static nominal strain range within that specimen for a specific applied load range. Best results can generally be obtained when the applied load range for the static calibration tests does not pass through zero load. Strain measurements shall be made at locations sufficiently distant from local effects, such as weld toes or bolt holes, which could significantly influence acquired test data.

2. As a minimum, eight strain gages shall be installed on the centerbeam top flange in the vicinity of each centerbeam-to-support bar connection. These gages shall be installed in pairs on each side of the connection at distances of one and two times the depth of the centerbeam from the centerline of the connection. Each pair of strain gages shall be located symmetrically about the centerline of the centerbeam. As a minimum, two strain gages shall also be installed on the support bar bottom flange in the vicinity of each centerbeam-to-support bar connection. One of these strain gages shall be installed on each side of the connection at a distance equal to the depth of the support bar from the centerline of the connection. These strain gages shall be installed along the centerline of the support bar.

D. Test Fixtures

1. Test fixtures shall have the capability to adequately support and secure the specimen throughout the duration of the test. The fixture shall be designed and fabricated to such tolerances as required to assure that additional stresses will not be generated in the specimen as a consequence of fixture misalignment. Mismatches resulting from specimen fabrication errors shall be accommodated by shimming or other such means precluding the application of force to the specimen.

2. Typical elastomeric bearings and springs used to transfer vertical loads from the support bars to the support boxes may be replaced with steel bearings in the test fixture. This modification will enable fatigue testing at higher load

ranges and different frequencies than those encountered during normal service conditions.

3. Load shall be applied through two 10 inch long patches. Each patch shall typically comprise a steel plate and a hard rubber bearing pad placed in contact with the bottom flange of the centerbeam. Each patch shall be located at midspan of each outer span.

4. In order to assure adequate seating of the specimen to the test fixture, a minimum of 10 kips shall be applied at each patch location. This requirement is waived for tests of single support bar systems conducted using load reversal. Once this load has been applied, all strain measuring devices shall be rebalanced to zero strain while the preload is maintained. An additional load approximately equivalent to the calculated load range shall be applied. Strain ranges shall be measured for the load range from 10 kips to the peak load. Each static calibration test shall be repeated three times while still maintaining a minimum 10 kips load at each load patch. The measured strain ranges from each repetition should vary by no more than 25% from the mean value. If the stress ranges are not repeatable, appropriate modifications shall be made to the test fixture.

E. Static Calibration Test

1. Prior to any fatigue resistance testing, a static calibration test shall be performed in order to validate the structural analysis model. The static calibration test shall be performed after attainment of stress range repeatability as described in Section 3.10.D.4 of this Special Provision. The structural analysis model shall be considered validated when calculated strain ranges are within ±25% of the measured strain ranges at every strain gage location.

2. For the purpose of reporting nominal fatigue resistance stress ranges at specific details, stress ranges determined through structural analysis of the model shall be preferred over stress ranges acquired directly from test measurements.

F. Test Procedure

1. A minimum of ten data points shall be required to establish the fatigue resistance of each detail. The centerbeam-to-support bar connection shall be considered as a single detail.

2. Several data points may be obtained from a single specimen by repairing the cracked sections of that specimen and resuming testing. Such repairs shall have minimal effect on the stress ranges at unfailed details still being tested. Data points derived from tests in which a repaired detail cracks again shall be discarded.

3. All data shall be in the very long life range, corresponding as closely to the constant amplitude fatigue limit as practical, but in no case less than 200,000

cycles. Either finite life regime or infinite life regime testing may be conducted. For infinite life regime testing, the number of cycles, N, associated with each of the ten data shall be at least twice the number of cycles, N_{min}, designated in the table in Section 3.10.G.1 of this Special Provision.

4. Loads shall be applied using hydraulic actuators or other similar loading devices. The magnitude of the vertical load range, ΔP_v, shall be maintained and continuously monitored throughout the duration of the test. Vertical and horizontal load ranges shall be applied to the specimen simultaneously. The horizontal load range shall always be equal to 20% of the vertical load range, ΔP_v. This horizontal-to-vertical load ratio may be maintained by inclining the specimen 11.3 degrees with respect to the horizontal plane and applying load through vertically oriented actuators.

5. For multiple support bar systems, the loading mechanism shall be either exclusively tension or exclusively compression and shall be applied at a constant amplitude at any desired frequency. The applied load range shall be in a direction such that the reaction force between the centerbeam and support bar is always tensile. The load range shall not pass through zero load. Minimum preload shall be maintained throughout the duration of the test.

6. Single support bar systems may be loaded using the same procedures as those for multiple support bar systems. If premature stirrup failure occurs, an applied load range of 70% compression and 30% tension may be used.

7. The load ranges used in the test shall not be so large as to alter the observed failure mode from that which would be observed under service conditions. Under no circumstance shall imposed stress exceed the yield stress of the material in any portion of the specimen. Each specimen shall be tested using at least two different load (stress) ranges.

8. If infinite life regime testing is conducted, the first load range should be chosen so that the applied stress range is just above the postulated CAFL. The load range in the subsequent test shall be decreased if failure resulted and increased if the test resulted in a runout. A suggested increment in load is such that the stress range is increased or decreased by 2 ksi. The applicable CAFL shall be selected from those CAFL values corresponding to the AASHTO fatigue categories. The selected CAFL is the one just below the lowest stress range that resulted in cracking.

9. The following criteria shall be used to define failure of a given centerbeam-to-support bar connection:

    a. Welded Centerbeam-to-Support Bar Connections

        1. *Centerbeam weld toe cracking* originates at or near the centerbeam weld toe, propagates up into the centerbeam at some angle, and grows back over the connection. These cracks typically grow at an angle of about 45 degrees. A specimen shall

be considered as failed due to this type of cracking when the crack has grown on any vertical face a length from the point of origin equal to half of the centerbeam depth.

2. *Support bar weld toe cracking* originates at or near the support bar weld toe, propagates down into the support bar, and grows back under the connection at some angle, typically about 45 degrees. A specimen shall be considered as failed due to this type of cracking when the crack has grown on any vertical support bar face a length from the point of origin equal to half of the depth of the support bar.

3. *Weld throat cracking* originates in the weld throat and typically grows in a plane parallel to the longitudinal axis of the support bar at about mid-depth of the weld throat. A specimen shall be considered as failed due to this type of cracking when a complete fracture of the weld throat has occurred. These cracks have been observed to turn down into the support bar, but only after significant growth. In such instances, the criteria for support bar weld toe cracking shall be applied.

b. Welded Stirrup Connections

1. A specimen shall be considered as failed when cracks result in the complete fracture of any stirrup leg or when cracks originating at or near a stirrup weld have grown into any face of the centerbeam a length from the stirrup weld toe equal to half of the centerbeam depth.

c. Bolted Centerbeam-to-Support Bar Connections

1. A specimen shall be considered as failed when:

i. Fatigue cracks which have grown out of a bolt hole have resulted in the complete fracture of the tension flange of the centerbeam.

ii. Fatigue cracks which have grown out of a bolt hole have extended into any face of the centerbeam web a distance equivalent to half of the centerbeam depth less the centerbeam flange thickness.

iii. Any portion of a stirrup fractures completely.

iv. Any single bolt fractures completely.

10. Alternate Criteria for Termination of a Finite Life Regime Test

a. A test may also be terminated when, for a given stress range, the specimen has survived the number of cycles required to plot the data above either a particular fatigue resistance curve or the maximum permitted in Section 3.10.G.2.d of this Special Provision. For example, if the applied stress range is 17 ksi and the desired fatigue resistance curve is Category C, then based upon the equation presented in Section 3.10.G.1 of this Special Provision, the test may be terminated after application of about 900,000 cycles provided that the specimen has not failed based on the above described criteria.

11. Nominal Stress Range Calculation

a. Welded Centerbeam-to-Support Bar Systems

1. The nominal stress range for centerbeam weld toe cracking shall be calculated by taking the square root of the sum of the squares of the longitudinal bending stress range in the centerbeam and the vertical stress range at the top of the weld.

2. The nominal stress range for support bar weld toe cracking shall be calculated by taking the square root of the sum of the squares of the longitudinal bending stress range in the support bar and the vertical stress range at the bottom of the weld.

3. The nominal stress range for weld throat cracking shall be the calculated vertical stress range in the throat of the weld.

4. The nominal stress range in the centerbeam at a welded stirrup shall be calculated as the summation of the longitudinal bending stress ranges at the critical section resulting from vertical and horizontal loading. The entire load range shall be used in the calculation, even if the loading is partly in compression. The effects of stresses in any load-bearing attachments such as the stirrup or yoke shall not be considered when calculating the nominal stress range in the centerbeam.

   The load range in the stirrup itself shall be taken as 30% of the total vertical load range carried through the connection. The effect of horizontal forces may be neglected.

b. Bolted Systems

1. The nominal stress range in the centerbeam shall be taken as the summation of the longitudinal bending stress ranges in the centerbeam resulting from vertical and horizontal loading. Nominal stress ranges shall be calculated using the net section. The effects of stresses in the stirrup shall not be considered when calculating the nominal stress range in the centerbeam.

2. The nominal load range in the bolt group and the stirrup assembly shall be taken as 30% of the total vertical load range carried through the connection. The effect of horizontal forces may be neglected.

G. Interpretation of Test Data

1. The experimentally acquired data and graphs representing the fatigue resistance of the detail categories delineated in Section 6.6 of the AASHTO LRFD Bridge Design Specifications - Second Edition shall be juxtaposed on a log-log scale. The equation representing the finite life fatigue resistance of these AASHTO detail categories is:

$$N \equiv A / S^3_{r,eff}$$

where:

$N \equiv$ number of cycles to failure.
$S_{r,eff} \equiv$ nominal effective stress range representing fatigue resistance.
$A \equiv$ constant defined in Table 6.6.1.2.5-1 of the AASHTO LRFD Bridge Design Specifications - Second Edition.

The minimum number of cycles associated with infinite fatigue life, N_{min}, and the corresponding constant amplitude fatigue limit (CAFL) for each AASHTO detail category is designated in the table below.

Detail Category	**N_{min} (infinite fatigue life)**	**CAFL(ksi)**
A	1.8×10^6 cycles	24
B	3.0×10^6 cycles	16
B'	3.5×10^6 cycles	12
C	4.4×10^6 cycles	10
C'	2.5×10^6 cycles	12
D	6.4×10^6 cycles	7.0
E	1.2×10^7 cycles	4.5
E'	2.2×10^7 cycles	2.6

2. Finite Life Regime Testing

a. The number of cycles, N, to either failure or runout, associated with each of the ten data need not exceed N_{min}, designated in the table in Section 3.10.G.1 of this Special Provision.

b. The detail category applicable to fatigue design shall be that corresponding to the highest of the AASHTO detail category fatigue resistance graphs representing a lower bound of all ten experimentally acquired data.

c. If all but one datum falls above a selected AASHTO S-N curve, that one datum may be discarded and replaced by three new data obtained through additional testing. The additional testing shall be conducted using the same stress range as that of the discarded datum. The three additional data shall be plotted along with the remaining nine data. The applicable detail category shall be that corresponding to the highest of the AASHTO detail category fatigue resistance graphs representing a lower bound of all twelve data, except as limited in the previous table. For any detail, only one datum may be discarded and subsequently replaced with three additional data for any set of ten original data.

d. The maximum fatigue resistance of any detail shall not exceed that associated with the fatigue category prescribed in the table below.

Type of Detail	Maximum Permitted Category
Welded Multiple Centerbeam-to-Support Bar Connections	C
Weld Stirrup Attachments for Single Support Bar Systems	B
Bolted Stirrup Attachments for Single Support Bar Systems	D
Groove Welded Centerbeam Splices[1]	C
Miscellaneous Welded Connections[2]	C
Miscellaneous Bolted Connections	D

Footnotes:

1. Groove welded full penetration splices may be increased to Category B if weld integrity is verified using non-destructive testing (NDT).
2. Miscellaneous connections include attachments for equidistant devices.

e. The fatigue resistance for stirrups welded to a centerbeam flange shall not be taken greater than that defined using the fatigue details defined in Section 6.6 of the AASHTO LRFD Bridge Design Specifications - Second Edition. The applicable fatigue detail for the centerbeam flange and for the stirrup shall be either a "Longitudinally Loaded Groove-Welded Attachment" or a "Longitudinally Loaded Fillet-Welded Attachment", depending upon the type of connection used.

3. Infinite Life Regime Testing

a. The applicable constant amplitude fatigue limit (CAFL) for fatigue design may be selected as the highest CAFL of the AASHTO detail categories representing a lower bound to the experimentally acquired data. The CAFL of the AASHTO detail categories are designated in the table in Section 3.10.G.1 of this Special Provision.

b. A unique CAFL (different from the CAFL categories delineated in Section 6.6 of the AASHTO LRFD Bridge Design Specifications - Second Edition) may be established if all ten data are within 4 ksi of that unique CAFL.

H. Data Reporting

1. Fatigue Test Results and Observations

a. Data shall be reported in the typical S-N format (logarithm(S) vs. logarithm (N)) with the log of the stress range plotted as the ordinate (y-axis).

Additionally, the data shall be reported in tabular format. The table shall contain the following information:

1. Nominal stress range at the specific detail, $S_{r,eff}$

2. Applied load range for each patch

3. Number of cycles at initial observation of cracking (for reporting purposes only, not included as S-N data)

4. Number of cycles at failure or termination of the test, N, and the reason for stopping the test (failure or termination)

5. Type of crack as described in Section 3.10.F.9 of this Special Provision. A detailed description of the fatigue crack shall be provided if the observed crack does not resemble any of the crack types described in Section 3.10.F.9 of this Special Provision.

2. Miscellaneous Required Information

a. The following information shall also be reported:

1. Expansion joint system type and manufacturer

2. Drawings depicting shape, size, and dimensions of the specimen

3. Drawings depicting fixture details, including specimen orientation

4. Section properties and dimensions of the centerbeam and support bar

5. Centerbeam-to-support bar connection details

i. Weld procedure specifications for welded expansion joint systems

ii. Bolt size, material specifications, location, and method of tightening for bolted expansion joint systems

3.11 Durability Testing of Elastomeric Support Bearings

A. Scope

1. This section provides guidelines for durability testing of the elastomeric support bearings typically used in modular expansion joint systems. It is not applicable to compression springs, equidistant springs, or other elastomeric components.

2. Tests shall be performed dynamically on individual bearings. Fatigue life is evaluated by applying a displacement range to each specimen rather than a load or stress range.

B. Specimens

1. Specimens shall comprise full scale bearing components representative of those installed in field applications. PTFE sliding surfaces or materials typically bonded to the elastomeric support bearings shall be fabricated as an integral part of the specimen.

2. Prior to testing, each specimen shall be visually inspected for any flaws or defects that could plausibly affect fatigue resistance. Any flaws or details shall be defined and recorded. Data obtained from specimens containing such anomalies shall not be excluded from the data set. Observed anomalies shall also be reported with the test data.

C. Test Fixtures

1. Test fixtures shall have the capability to adequately support and secure the specimen throughout the duration of the test. The fixture shall be designed and fabricated to such tolerances as required to assure that additional stresses will not be generated in the specimen as a consequence of fixture misalignment.

D. Loading Details

1. Loads shall be applied through hydraulic actuators or other similar loading devices. Fatigue testing shall be performed using displacement control. Displacement and load ranges shall be continuously monitored throughout the duration of the fatigue test to assure that desired displacement range and minimum preload are maintained.

2. Load shall be applied to the specimen through flat steel plates that are smooth and free of surface corrosion. These plates shall be sufficiently thick to assure even load distribution to the specimen.

E. Dynamic Stiffness Test

1. Testing shall be conducted on each specimen to be subjected to fatigue testing in order to establish its dynamic stiffness for at least three different loading frequencies. The maximum of these loading frequencies shall be equal to the service load frequency corresponding to a vehicle traveling at 60 mph. The loading frequency, f, shall be calculated as:

$$f \equiv 0.5 \cdot V / (g + b)$$

where

$V \equiv$ vehicle speed (60 mph at service load)

$g \equiv$ centerbeam gap (assume mid-range configuration)
$b \equiv$ centerbeam width

2. The load range applied during the dynamic stiffness test shall be that obtained from structural analysis using fatigue wheel load and wheel load distribution factors as specified in Section 3.04 and Section 3.05 of this Special Provision.

3. Each dynamic stiffness test shall be performed three times. Data from individual tests shall be compared to assure consistency of test results.

F. Fatigue Test

1. A minimum of three fatigue tests shall be required to establish the durability of each type of bearing.

2. The fatigue test shall be conducted using displacement control. The displacement (strain) range shall be applied using a sine or other smooth waveform at any frequency less than or equal to the service load frequency calculated in Section 3.11.E of this Special Provision. The magnitude of the applied displacement amplitude, Δ, shall be calculated as:

$$\Delta \equiv R_V / K$$

where

$R_v \equiv$ vertical reaction force at the support bearing as obtained from structural analysis
$K \equiv$ dynamic stiffness of the support bearing as determined in Section 3.11.E of this Special Provision

3. A minimum precompression strain shall be maintained in the specimen throughout the duration of the test. This precompression strain shall be approximately equal to that present in a support bearing in a field installation. The magnitude of the applied cyclic strain shall be at least equal to the precompression strain.

4. The minimum and maximum dynamic load shall be recorded at the beginning of the test. The minimum and maximum dynamic load shall be monitored and periodically recorded throughout the duration of the test.

5. At the end of each applied displacement cycle, the displacement shall be held at the precompression level for no less than one half of the period of loading in order to facilitate heat dissipation. Artificial air flow devices (electrical fans) may be used to assist heat dissipation. Excessive heat generation will adversely affect the tested fatigue life.

6. A specimen shall be accepted as having passed the fatigue test criteria after withstanding 2 million cycles of loading without failure.

7. The following criteria shall constitute failure:

   a. The elastomeric material exhibits excessive deterioration or cracking.

   b. The measured minimum dynamic load falls to 30% of the initial dynamic load recorded at test initiation.

   c. The measured dynamic load range decreases to half of the initial dynamic load range recorded at test initiation.

G. Data Reporting for Fatigue Test

1. Data shall be reported in tabular format and shall contain the following information for each specimen tested:

   a. Minimum (precompression) strain, maximum strain, displacement, and load at test initiation

   b. Type of loading impulse (sine wave, ramp, etc.)

   c. Number of cycles at initial observation of distress leading to failure (for reporting purposes only, not to be included in the data)

   d. Number of cycles at failure

   e. A description of the mode of failure

2. The following data shall also be reported for each specimen tested:

   a. Bearing type and manufacturer

   b. Drawings depicting shape, size, and dimensions of the specimen including any PTFE sliding surfaces or materials bonded to the specimen

   c. Drawings depicting fixture details, including specimen orientation.

3.12 Testing Laboratory

A. Fatigue testing shall be performed by an independent testing laboratory. The following individuals have stated that they have access to facilities capable of performing the fatigue testing:

1. Prof. Charles W. Roeder
Department of Civil Engineering
233B More Hall
University of Washington
Seattle, WA
Tel: (206) 543-6199
Fax: (206) 543-1543

2. Dr. John W. Fisher
ATLSS Research Center
Lehigh University
117 ATLSS Drive
Bethlehem, PA 18015-4793
Tel: (215) 758-3535
Fax: (215) 758-5553

3. Prof. Robert J. Dexter
Department of Civil Engineering
University of Minnesota
122 CivE
500 Pillsbury Drive S.E.
Minneapolis, MN 55455-0220
Tel: (612)-624-0063
Fax: (612)-626-7750

3.13 Fatigue Testing Reference

A. Provisions contained in Sections 3.10 and 3.11 of this Special Provision have been developed from research summarized in National Cooperative Highway Research Program Report 402 "Fatigue Design of Modular Bridge Expansion Joints", National Academy Press, Washington DC, 1997.

3.14 General Fabrication Requirements

A. The expansion joint systems shall be fabricated consistent with the details, dimensions, material specifications, and procedures delineated in the approved shop plans. All fabrication procedures shall be in conformance with the Standard Specifications and the Special Provisions.

B. All expansion joint systems shall be fabricated by the same manufacturer.

C. Metallic attachments used to secure elastomeric seals to the centerbeams, if welded to the centerbeams and edge beams, shall be welded continuously along both their top and bottom edges.

3.15 PTFE Sliding Surfaces

A. All PTFE shall be bonded under controlled conditions and in strict accordance with written instructions provided by the PTFE manufacturer.

B. All PTFE surfaces shall be smooth and free of bubbles after completion of bonding operations.

3.16 Stainless Steel Sliding Surfaces

A. All stainless steel sliding surfaces in contact with PTFE shall be polished to a Number 8 mirror finish.

B. Each stainless steel sheet shall be welded to the steel backing plate in accordance with current AWS specifications. The stainless steel sheet shall be clamped to provide full contact with the steel backing plate during welding. The welds shall not protrude above the sliding surface of the stainless steel sheet.

3.17 Corrosion Protection

A. All steel surfaces, except those surfaces beneath stainless steel sheet, those to be bonded to PTFE, or those in direct contact with strip seals, shall be protected against corrosion by one of the following methods:

1. Zinc metallized in accordance with the Special Provision **METALLIC COATINGS**.

2. Hot-dip galvanized per AASHTO M 111.

3. Painted in accordance with Section 6-03.3(30) as supplemented in these Special Provisions. The color of the final coat shall be Washington Gray (revised). The surfaces embedded in concrete shall be painted only with a shop coat of inorganic zinc silicate paint.

3.18 Inspection

A. Each expansion joint system shall be subjected to and shall pass three levels of inspection in order to be accepted. These three levels are Quality Control Inspection, Quality Assurance Inspection, and Final Inspection. The manufacturer shall provide both Quality Control Inspection and Quality Assurance Inspection. The Contractor shall provide access to the Engineer for the Final Inspection.

B. *Quality Control Inspection* shall be provided by the manufacturer on a full time basis during the fabrication process of all major components to assure that the materials and workmanship meet or exceed the minimum requirements of the contract. *Quality Control Inspection* shall be performed by an entity having a line of responsibility distinctly different from that of the manufacturer's fabrication department.

C. *Quality Assurance Inspection* shall be performed by an independent inspection agency provided by the manufacturer. *Quality Assurance Inspection* is not required to be full time inspection, but shall be performed during all phases of the manufacturing process.

D. *Final Inspection* of each expansion joint system will be performed by the Engineer at the job site immediately prior to installation. The Contractor shall provide an accessible work area for this inspection. During *Final Inspection*, the Engineer will inspect each expansion joint system for proper alignment, complete bond between expansion joint strip seals and steel components, and proper steel stud placement. There shall be no bends or kinks in the steel components, except as required to follow roadway grades and as specifically detailed on the approved shop plans. Straightening of unintended bends or kinks will not be permitted. Any expansion joint system exhibiting bends or kinks, other than those shown on the approved shop plans, shall be removed from the job site and replaced with a new expansion joint system at the expense of the Contractor. Expansion joint strip seals not fully bonded to the steel shall be fully bonded at the expense of the Contractor. Studs will be visually inspected and will be struck lightly with a hammer. Any stud which does not have a complete end weld or does not emit tintinnabulation when struck lightly with a hammer shall be replaced. Any stud located more than one inch, in any direction, from the location specified on the shop plans shall be carefully removed and a new stud shall be welded in the proper location. All stud replacements shall be at the expense of the Contractor.

3.19 Acceptance

A. Each expansion joint system shall pass all three levels of inspection delineated in Section 3.18 of this Special Provision to qualify for acceptance. Any expansion joint system which fails any one of the three levels of inspection shall be replaced or repaired at no expense to the Contracting Agency and to the satisfaction of the Engineer. Any proposed remedial procedures shall be submitted to the Engineer for approval before implementation.

B. The Contractor shall ascertain that the manufacturer has met the fatigue resistance characterization and prequalification requirements of Sections 3.01.A and 3.02.A of this Special Provision applicable to the specific expansion joint system being installed. The Contractor shall be responsible for any additional costs and/or time delays associated with selection of an alternative expansion joint system incurred as a result of noncompliance with these requirements, including the failure of the manufacturer to retest revised details or material substitutions of a previously prequalified system.

3.20 Shipping and Handling

A. The expansion joint system shall be delivered to the job site and stored in accordance with the manufacturer's approved shop plans.

B. Lifting mechanisms, temperature adjustment devices, and temporary anchorages shall not be welded to the centerbeams or edge beams.

C. Damage to the expansion joint system during shipping or handling shall be just cause for rejection of the expansion joint system.

D. Damage to the corrosion protection system shall be repaired to the satisfaction of the Engineer.

3.21 Installation

A. A qualified installation technician shall be present at the job site to assure proper installation of each expansion joint system. This technician shall be a full time employee of the manufacturer of the specific expansion joint system being installed. The Contractor shall comply with all recommendations made by the expansion joint manufacturer's installation technician as approved by the Engineer.

Each expansion joint system manufacturer's installation technician shall certify to the Engineer that the approved installation procedures were followed. All certifications to the Engineer shall be in writing and shall be signed and dated by the manufacturer's installation technician.

B. Each expansion joint system shall be installed in strict accordance with the manufacturer's approved shop plans as stipulated in Section 3.02.B.1 of this Special Provision and the recommendations of the manufacturer's installation technician. All centerbeam welded field splices shall be performed by a certified welder under the direct supervision of the manufacturer’s qualified installation technician specified in Section 3.21.A of this Special Provision. The weld procedure shall have been submitted by the manufacturer and approved in accordance with Section 3.02.B.1.i of this Special Provision. The welder shall have been trained and certified for performing those approved specific welds in accordance with the current AASHTO/AWS D1.5 Bridge Welding Code.

C. Each permanently installed expansion joint system shall match exactly the finished roadway profile and grades.

D. The Contractor shall exercise care at all times to protect each expansion joint system from damage. The Contractor shall protect concrete blockouts and supporting systems from damage and construction traffic prior to installation of the expansion joint systems. After installation, construction loads shall not be allowed on the expansion joint systems. The Contractor shall submit to the Engineer for approval a proposed method of bridging over each expansion joint system to accommodate any construction traffic.

E. Each expansion joint system shall be set to a gap width corresponding to the ambient temperature at the time of setting. This information is specified in the Plans and shall also be specified on the approved shop plans. Any mechanical devices supplied by the joint system manufacturer, for the purpose of setting the expansion joint system to the proper gap width, will remain the property of the manufacturer. When no longer required, the devices shall be returned to the manufacturer.

F. All forms and debris that may impede movement of the expansion joint systems shall be removed.

G. Each expansion joint system shall be tested for watertightness after installation. The Contractor shall flood each completely installed expansion joint system with water to a minimum depth of 3 inches for a duration of at least one hour. If leakage is observed, the expansion joint system shall be repaired to the satisfaction of the Engineer at the Contractor's expense. The repair procedure shall be prepared by the expansion joint system manufacturer and shall be submitted to the Engineer for approval. After repairs are completed, the expansion joint shall be retested for leakage.

Payment

4.01 Modular Expansion Joint System

A. The lump sum contract price for "Modular Expansion Joint System - Superstr." shall be full payment for all materials, labor, tools, equipment, design, testing, inspection, services, and incidentals necessary to furnish and install the expansion joint systems as specified.